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MECHANICAL SIZING OF CELERY STALKS BY WEIGHT

Marketing Research Report No. 822

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Preface

This report is based on research that is part of a broader project to develop more efficient work methods, equipment, and facilities for handling and preparing fruits and vegetables for market at Florida shipping points.

The work was conducted under the supervision of Earl K. Bowman and Joseph F. Herrick, Jr., Transportation and Facilities Research Division, Agricultural Research Service, U.S. Department of Agriculture, and D. T. Kinard, Florida Agricultural Experiment Station.

The authors wish to express their appreciation to and acknowledge the cooperation of the following: A. Duda & Sons, Oviedo, Fla., and their staff who supplied celery stalks and a grant to purchase one of the electronic scales used in this study; the Agricultural Engineering Department, University of Florida, which provided part of the equipment necessary for the research and facilities for the laboratory phase of the tests and also moved the equipment to a commercial packinghouse for further testing; and Richard Sias, Illumitronic Scale Corp., Winter Park, Fla., who provided assistance and advice concerning the electronic scales.

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MECHANICAL SIZING OF CELERY STALKS BY WEIGHT

by

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Summary

Two small-package scales were tested to determine the feasibility of separating celery stalks by weight. One scale was a three-channel classifier that diverted stalks weighing more or less than the standard weight range set on the machine. The celery stalks were transported across the weighing platform by a moving belt. The displacement of the platform was electronically sensed, and the stalks were separated into one of three weight groups. The other scale operated similarly, but separated the stalks into only two groups.

Although fewer problems were encountered with the two-channel classifier than with the three-channel classifier, either would be adequate for sizing celery. The three-channel classifier weighed with an accuracy of ±0.058 pound at a rate of 200 stalks per minute.

For comparison, a monorail conveyor sizer was evaluated. This weighed with an accuracy of ±0.088 pound at a rate of approximately 90 stalks per minute.

This sizer was a mechanical-beam type that has been in general use to size poultry carcasses for a number of years. The weighing system consisted of an overhead monorail conveyor from which stalk carriers were suspended. When the weight of the stalk plus the carrier was sufficient to depress a section of conveyor track, the carrier was dumped and the stalk fell onto a conveyor belt that transported it to the packers.

All of the mechanical scales that were evaluated sized celery stalks more accurately than the commonly used hand-sizing method.[2] When workers hand-sized stalks, accuracy was reduced to approximately ±0.394 pound.

Introduction

In Florida most growers harvest and pack celery in the field on a mobile packing vehicle, commonly referred to as a "mule train." Each celery grower owns from one to ten mule trains, and can harvest and pack between 2,000 and 3,500 crates per day on each vehicle. The annual output for individual Florida celery producers ranges from approximately 300,000 to 2,000,000 crates per year.

Workers on the ground precede the mule train, sever the celery stalk root with a knife, break unwanted outer petioles from the stalk, and place the stalk on the mule train wing belt conveyor. This conveyor transports celery stalks to the front of the mule train where the stalks are cut by machine to a standard length of 16 inches, dropped onto a central belt conveyor, and spray washed. Workers riding on the mule train pick up celery stalks from the conveyor and pack them in wire-bound crates.

The sizing method presently used is hand-sizing by the packer on the mule train. Celery sizes usually packed are referred to as 2, 2½, 3, 4, 6, or 8. These sizes designate the number of dozens of stalks packed in each crate.

Each packer on the mule train is assigned responsibility for packing only one size. The packers are responsible for selecting the proper size, breaking undesirable petioles from the stalk, and packing the correct number of stalks in each crate.

Accepted criteria for a good celery pack are that it have stalks of fairly uniform size, the proper count per crate, and a slightly bulged lid. The pack should weigh from 60 to 65 pounds.

The packed crates are stacked on a truck towed behind the mule train, then transported to a pre-

[1] Final work on revision of the manuscript for this report was done by Frederick E. Henry, industrial engineer, Transportation and Facilities Research Division, Agricultural Research Service.

[2] Workers pick up the stalks and visually determine their size.

cooling plant, and cooled in hydrocooling tunnels. The individual crates are manually handled many times between packing and shipping.

A systems engineering study was made of the celery harvesting, handling, and packing system; and a new handling system was designed, based on a central packing and precooling plant. A feasibility study was made of this system and of other systems that pack the celery in the field. The study indicated that the central packing–precooling plant system offered the most potential for economies. Labor and equipment costs for the central packing–precooling plant system and for mechanical harvesting of the celery were estimated to be 30.2 cents per crate, a saving of 18.1 cents per crate over the present field-packing system.

To make full use of the economic potential of the central packing-precooling plant system, the celery should be harvested mechanically, hauled in bulk to the packinghouse, mechanically sized, and precooled in unit loads (stacks of 32 crates). A unit-load hydrocooling system has been designed and shown to be feasible for precooling stacked crates of celery.[3]

A study by Gull [4] was made to ascertain the uniformity of celery stalks within crates, to determine the average weight and diameter of celery stalks, to evaluate the average crate weight being packed by growers, and to determine the feasibility of mechanical sizing. He measured the weight of stalks and the diameter of the stalk base when placed under moderate compression. These measurements were made on about 6,000 stalks of celery. A correlation coefficient between diameter and stalk weight was calculated to be 0.957, indicating a linear relationship. Gull concluded that the present method of hand-sizing celery does not produce a uniform pack because of the considerable overlap of celery sizes within the crates packed in the field.

Based on this study by Gull, a test was made to check the feasibility of packing weighed stalks into crates. Several crates that had been packed on mule trains were unpacked; the stalks were weighed and separated into groups; and then the crates were repacked.

Weight limits for the sized groups were initially established by using the average stalk weight required to obtain a 61- to 62-pound total crate weight. Several crates were packed with the sized stalks. Total crate weight averaged 61.62 pounds for size 2, 61.82 pounds for size 2½, and 61.41 pounds for size 3. Total crate weight for a few crates packed in the field averaged 60.94 pounds for size 2, 61.65 pounds for size 2½, and 59.50 pounds for size 3.

Analysis of the standard deviation and weight ranges of packed crates indicated that if celery is sized by weight, the weight ranges would be reduced by an average of nearly 5 pounds. This would mean that total crate weight would be less subject to variation, workers would have little problem in packing weight-sized celery into crates, and packs would be neither too slack nor too full.

The present study was made to evaluate mechanical sizing of celery. For a mechanical sizer there were two choices: A dimension sizer or a weight sizer. The weight sizer was chosen for study because it is the simpler of the two mechanisms.

Two types of weight sizers were studied. The first was an electronic scale, with a belt running over the weighing platform. As the product is transported across the platform, it is quickly weighed by the scale and classified into a weight category.

The second was a monorail conveyor sizer. Suspended from the conveyor are regularly spaced carriers on which celery stalks are placed. The carrier hanger rides on the conveyor track, which is broken at several places along its length for the mechanical beam-type weighing mechanism. When the weight of the stalk plus the carrier is sufficient to depress a section of track, the carrier is dumped and the stalk falls onto a belt conveyor that carries it to the packers.

Either of the two types of sizers would fit into a packinghouse and perform the function of mechanical sizing. The electronic scale was selected for detailed evaluation for the following reasons: Greater accuracy potential, higher speed of operation, lower initial cost, and smaller plant floorspace requirement.

Description of the Three-Channel Electronic Scale and Conveyor System

Scale Operation

The scale chosen for detailed evaluation was a commercial model, small-package electronic scale that classified celery stalks into three weight groups. It was equipped with a belt that transported the stalk over a weighing platform, causing a vertical displacement of the platform directly proportional to the stalk weight (fig. 1). Change in platform position was converted by a transducer into voltage change. The magnitude and phase of this voltage were detected by the electronic unit that controlled the lights and the classifying diverters of the system.

[3] Grizzell, W. G., and Bennett, A. H. hydro-cooling stacked crates of celery and sweet corn. U.S. Agr. Res. Serv. ARS 52–12, 40 pp., illus. 1966.

[4] Gull, Dwain D. homogenity of sized celery in florida. Fla. State Hort. Soc. Proc. 77: 137–143. 1964.

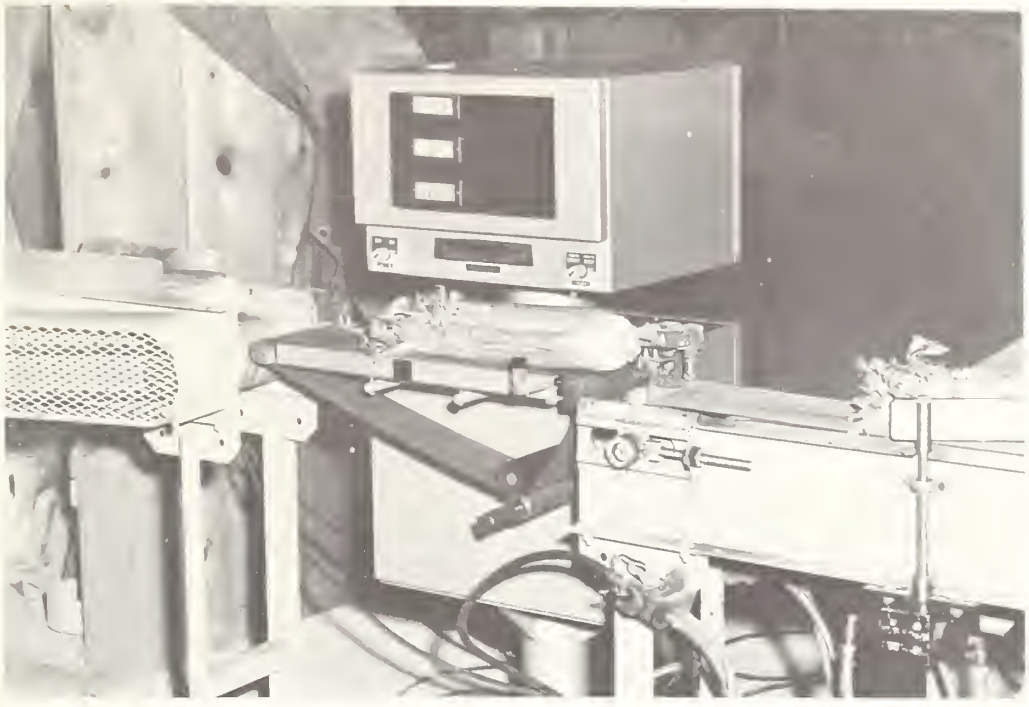


FIGURE 1.—Three-channel electronic scale with celery stalk on weighing platform. Stalks move onto scale from left.

If the celery stalk weighed more or less than the standard weight range, the scale became unbalanced and through impulses from the electric circuitry activated the diverter paddles. In this manner, celery stalks were separated into three weight groups: Those weighing less than the acceptable weight range set on the scale; those weighing within the acceptable weight range; and those weighing more than the acceptable weight range.

By adjusting a control dial, the speed of the weighing platform belt could be matched to the speed of the belt feeding celery onto the scale.

The unit was equipped with controls to adjust damping [5] and the midpoint of the acceptable weight range. A control was also added to widen or narrow the limits of the acceptable weight range.

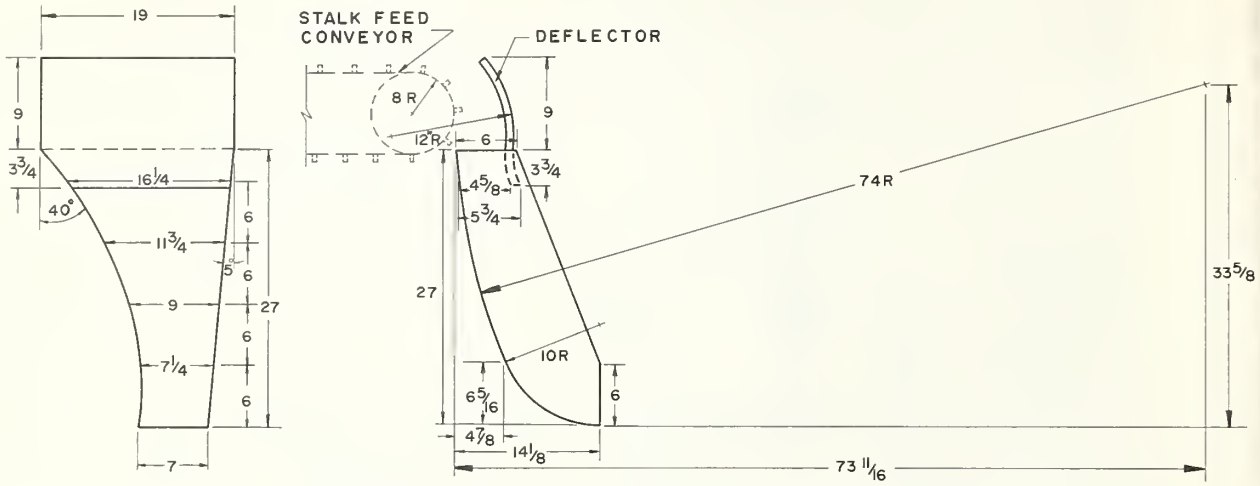
Stalk Spacing System

For the tests to evaluate the three-channel electronic scale, stalk spacing belt conveyors were installed to regulate the speed of the celery stalks and to space stalks moving onto the scale. A take-away belt conveyor was also installed to transport the sized stalks away from the scale.

FIGURE 2.—Feed belt conveyor with rubber spacers 6 inches apart.

[5] Time required to stabilize the weighing platform after arrival of celery stalk on the scale.

Celery stalks were fed onto the weighing platform at rates up to 200 stalks per minute. These stalks were placed perpendicular to the direction of travel on a slow-moving, 20-inch-wide feed belt conveyor to which spacers at 6-inch centers had been attached (fig. 2). This conveyor had an adjustable speed drive to vary stalk input rates for tests.



NOTE: CHUTE CUT FROM 22 GA. GALV. SHEET METAL AND SOLDERED INTO UNIT ATTACHED TO CONVEYOR FRAME WITH BRACKET AND ¼" BOLTS.
DEFLECTOR MADE FROM 22 GA. GALV. SHEET METAL CUT 13¾" x 19¼" WITH ⅛" ROLL ON EACH SIDE CURVED TO GENERAL CONTOUR OF CONVEYOR DRIVE DRUM, APPROX. 12" RADIUS.
ALL MEASUREMENTS IN INCHES.

FIGURE 3.—Drawing of celery stalk drop chute.

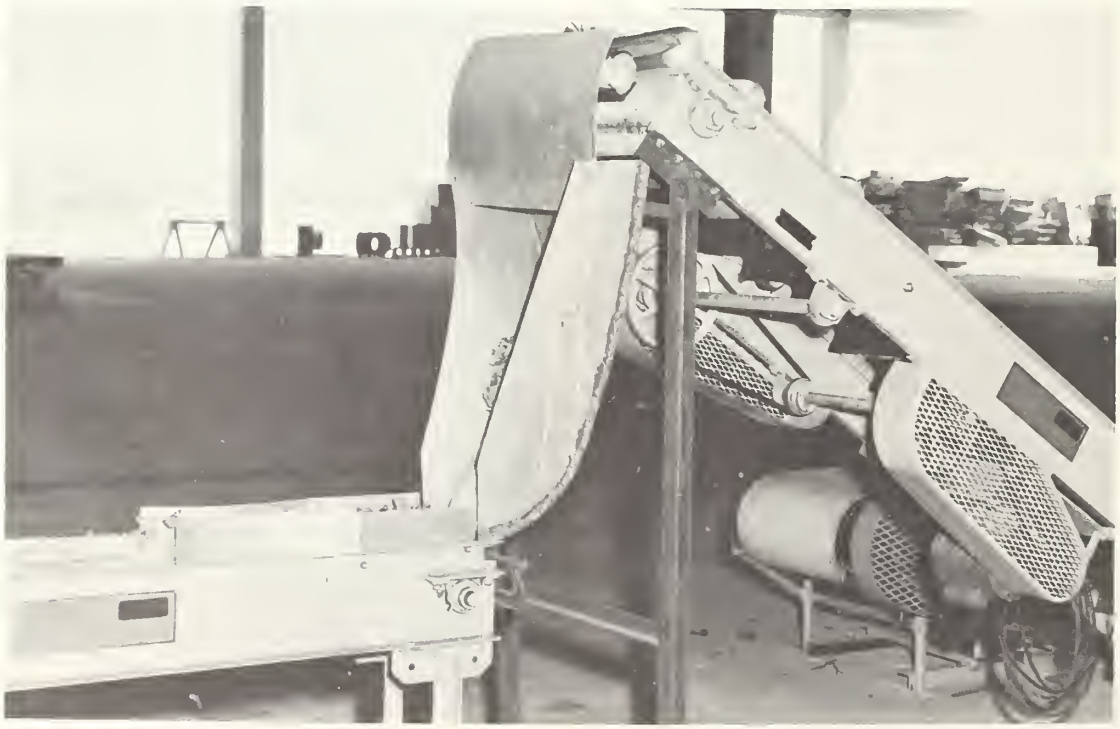


FIGURE 4.—Attachment of drop chute to slow-moving feed belt.

At the discharge end of the slow-moving feed belt, a galvanized sheet metal chute was attached (fig. 3). Celery stalks dropped from the end of the belt, entered the chute (fig. 4), were turned 90° to a butt-leading orientation, and exited at near the velocity of the section of the stalk spacer belt immediately following the drop chute (about 250 feet per minute) (fig. 5).

Next the celery stalks moved over a series of three 6-inch-wide spacer belts. Each spacer belt was adjusted to operate at increasingly higher speeds. This speed differential separated celery stalks by 4 to 5 inches as they moved from a slower to a faster belt (fig. 6). The speed of the spacer belt just before the scale was approximately 400 feet per minute.

Stalk Diverting Mechanism

Celery stalks weighed on the scale were transported by another 6-inch-wide belt to the stalk diverting mechanism. This mechanism had two air-operated, stainless steel paddles.

One paddle was installed on each side of the belt with the pivot end of the paddle on the downstream side. The diverter paddles were 2⅛ inches wide by 14¼ inches long. They were attached to a shaft actuated by a compressed-air rotary cylinder. Air pressure of 80 pounds per square inch operated the cylinder. Relays within the scale opened and closed the electric circuit to the solenoid valves to control action of the compressed-air rotary cylinders and diverter paddles.

Celery stalks classified overweight were diverted by one of the stainless steel paddles onto a holding table (fig. 7). Stalks classified underweight were diverted by the other paddle onto a second holding table. Stalks classified acceptable remained on the belt.

FIGURE 5.—Celery stalks dropping from chute onto the stalk spacer belt.

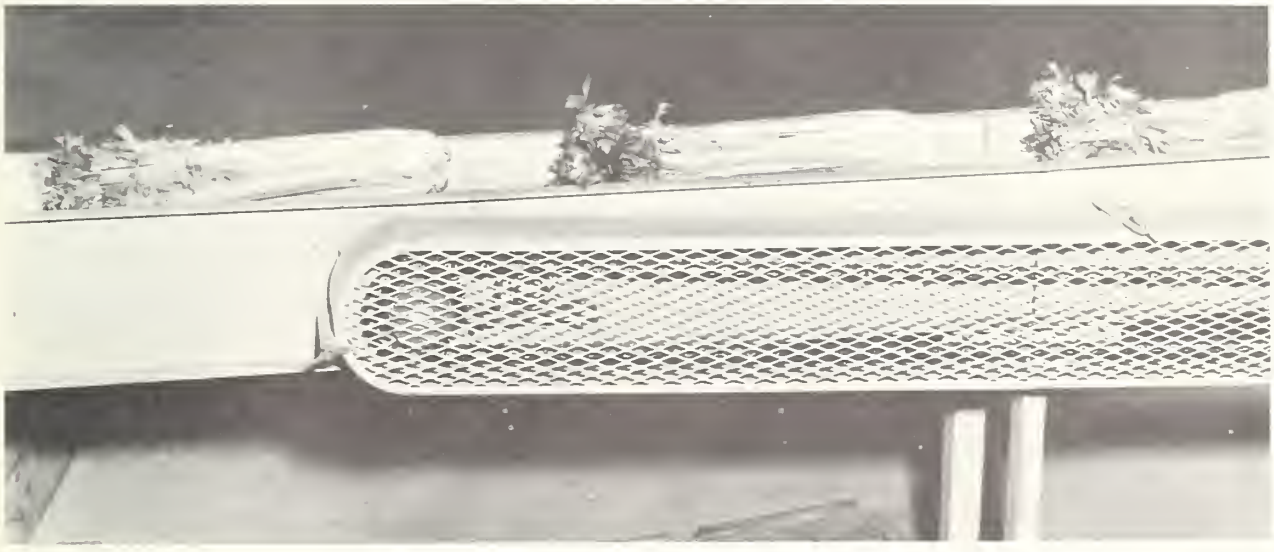


FIGURE 6.—Separation of celery stalks on spacer belts.

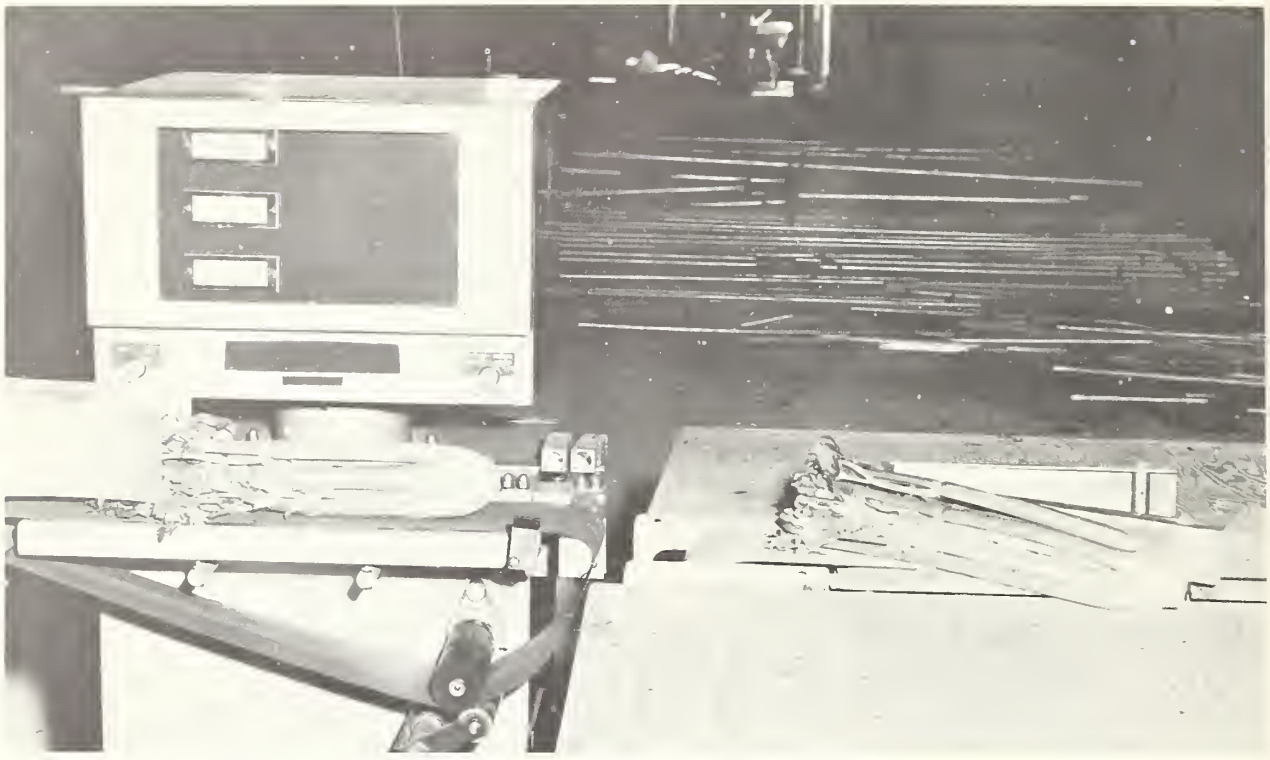


FIGURE 7.—Stainless steel paddle diverting celery stalk into overweight category.

Description of Tests of the Three-Channel Electronic Scale and Results

Tests with the three-channel electronic scale were conducted in both University of Florida laboratories and pilot facilities provided by a celery grower. Tests included trial runs with celery stalks of various sizes at various rates of delivery.

Acceptable Weight Zone Test

The acceptable weight zone test measured the range of weights that were classified acceptable by the scale. During the test, the weight range control setting was adjusted to several different values. Celery stalks of various sizes were fed onto the scale and the weight was recorded for each stalk classified in the acceptable zone.

When the weight range control was set at maximum (100%) under static conditions, the acceptable zone range was 0.388 pound. At other control settings, the acceptable zone ranges were as follows: 80 percent, 0.3 pound; 60 percent, 0.218 pound; 50 percent, 0.183 pound.

When the weight range control was set at 100 percent under dynamic conditions with the weighing platform belt in operation, the acceptable zone range was 0.59 pound. At 80 percent control setting, the acceptable zone range was 0.45 pound. The desired weight range for any one size of celery stalks is approximately 0.4 pound. The range of stalk weights classified as acceptable, therefore, is more than adequate for this purpose.

Scale Accuracy

An expression of scale accuracy is termed zone-edge width. The zone edge may be called an "area of indecision." It means that the scale will not accurately separate all stalks below a certain absolute weight from all those exactly that weight or over. Instead, there is an area on each side of a given weight in which stalks may be classified on either one side of the line or the other (fig. 8). As the width of this area increases, scale accuracy decreases. The zone-edge width will increase with increasing stalk weight (stalk length held constant). The zone-edge width will also increase with an increasing number of items being weighed per minute.

All scales are subject to this basic mechanical error, caused principally by friction and vibration.

During static test of zone-edge width, weights were removed from the weighing platform until the scale indicated underweight. Weights were then added to the platform until the scale indicated acceptable. The difference between these two weights was 0.022 pound.

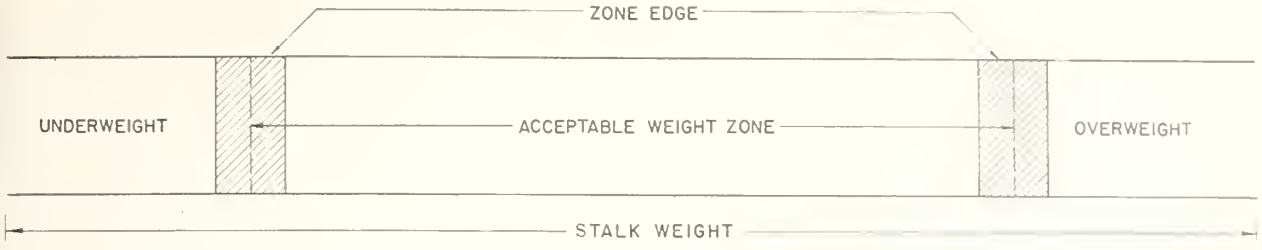


FIGURE 8.—Graph of acceptable stalk weight and zone-edge width.

During a dynamic test of zone-edge width, celery stalks weighing approximately 2 pounds were transported across the weighing platform at a belt speed of 420 feet per minute. The difference between acceptable and underweight was 0.115 pound. Scale accuracy can, therefore, be described as ±0.058 pound (½ of 0.115 pound).

Effect of Belt Speed on Scale Accuracy

Other dynamic tests for scale accuracy were made with a wood roller (simulated celery stalk) at various belt speeds. The diameter of the roller was approximately 2½ inches and each end was padded to minimize roll during transfer from the feed belt to the weighing platform. The weight of the wood roller was varied by adding or removing weights from a hole drilled in its center.

Weights were gradually removed from the wood roller, and the roller was transported across the weighing platform until the scale always indicated "underweight." The weight of the roller was then increased until it was in the acceptable weight zone. In this manner, lower and upper limits of the zone edge were established for four weighing platform belt speeds, ranging from 300 to 377 feet per minute. Zone-edge width ranged from 0.152 pound at a belt speed of 300 feet per minute downward to 0.072 pound at 377 feet per minute (fig. 9).

Surprisingly, this test indicated that the scale was more accurate at the highest belt speed. This result conflicted with data published by the scale manufacturer. On the basis of other tests conducted with celery stalks, however, the zone-edge width apparently would have increased at higher belt speeds had the tests been continued (0.115 pound at 420 feet per minute).

Effect of Stalk Spacing on Scale Accuracy

During initial test, we determined that the spacing between stalks was critical. If two stalks had less than 8½ inches of clear space between them, the second stalk would usually be misclassified.

To test the importance of the stalk spacing, an adjustable spacer device was installed on the feed belt. This device could exactly locate stalks at 23- to 28-inch centers. Clear space between stalks ranged from 7 to 12 inches.

This scale always misclassified the second stalk if only 8 inches of clear space was between it and the preceding stalk. When stalks were located on the feed belt at 25-inch centers and with 9 inches of clear space between them, they could be weighed at 200 stalks per minute and only 3 percent of the stalks would be misclassified. At this rate of handling stalks, the belt on the weighing platform operated at 426 feet per minute and the feed belt at 416 feet per minute.

Problems Encountered During Tests

Several problems were encountered during the tests; most of these were related to the high rates of speed at which the stalks were handled. These problems included stalk spacing variations, piling of stalks on the conveyor belts, stalks alined off-center on belts, poor belt performance when water was on the weighing platform, and inaccuracy caused by stalk spacing and belt speed requirements during field tests.

Stalk Spacing Variations

Stalks that were too closely spaced on the feeding conveyors were often improperly classified. If stalks were too close and the first stalk was overweight, the second stalk would always be classified overweight. This occurred even though the second stalk was underweight. Yet when the first stalk was underweight, the second, heavy stalk would occasionally be properly classified.

A possible solution of this problem is to install photoelectric cells 25 inches apart on the feed belt preceding the scale (fig. 10). Stalks that have less than 9 inches of clear space between them will cause the system to operate a reject paddle and to deflect the second stalk from the feed belt. The rejected stalk is then conveyed to the head of the line and placed into the system again.

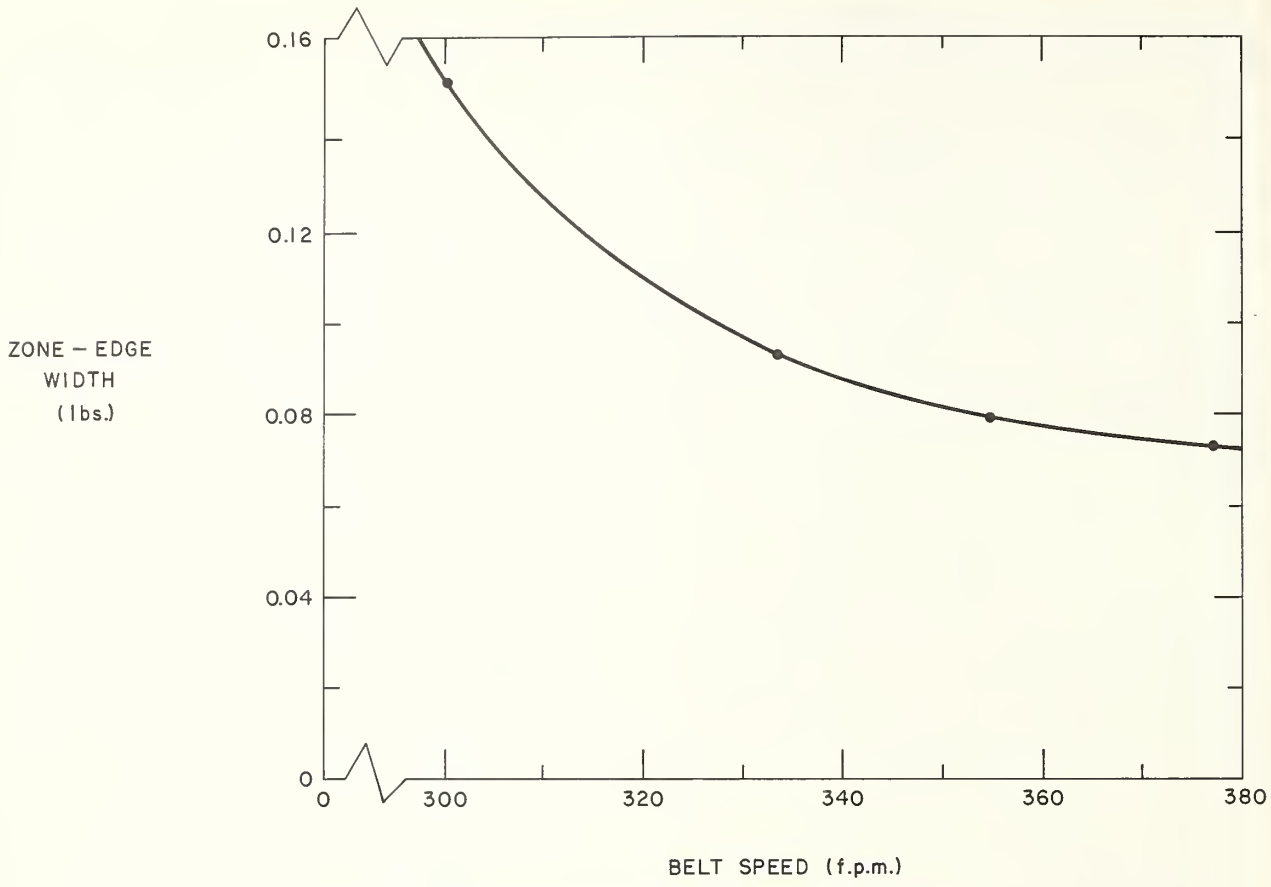


FIGURE 9.—Graph of zone-edge width of scale at four belt speeds.

Stalk Pileup on Conveyor Belts

Pileup on the conveyor belts occurred most often when a celery butt hit the tip of the stainless steel diverter paddles.

During three-channel separation of celery stalks, the tip of the diverter paddle was pointed upstream. Slight deviations in stalk speed translation or stalk centering on the conveyor belt affected the system by causing the tip of the paddle to be in position where the butt end of the celery stalk could hit the tip of the paddle. A celery stalk, once it had been stopped or slowed on the take-away belt, soon caused a general pileup of celery stalks.

This problem was eliminated, however, when the stalk diverting mechanism was installed with the pivot end of the paddle pointing upstream and the tip of the paddle pointing downstream. Stalks diverted from the belt were deflected by the paddle as it rotated into the path of the stalk (fig. 11). Slight deviations of speed or position of the stalk had no adverse effect on the system. However, the pivot end of the paddle should not be mounted so close to the conveyor belt that a stalk not well centered on the belt could hit any part of the mechanism.

Stalk Alinement on Belts

Stalks alined off-center on the 6-inch-wide spacer belts were often a problem. This was eliminated by installing flexible stainless steel plates with 13-inch flap sections on each side of the final spacer belt. An off-center stalk on the belt, when passing between these two plates, was slightly deflected and centered on the belt.

Weighing Platform Belt Performance

When selecting an electronic scale, care should be taken that water has no effect on the performance of the weighing platform conveyor belt. For example, one of the tested scales had a smooth, flat platform on which the belt rode while it transported the celery stalks. Water between the belt and the platform caused suction and additional drag on the belt, thereby slowing the speed of the

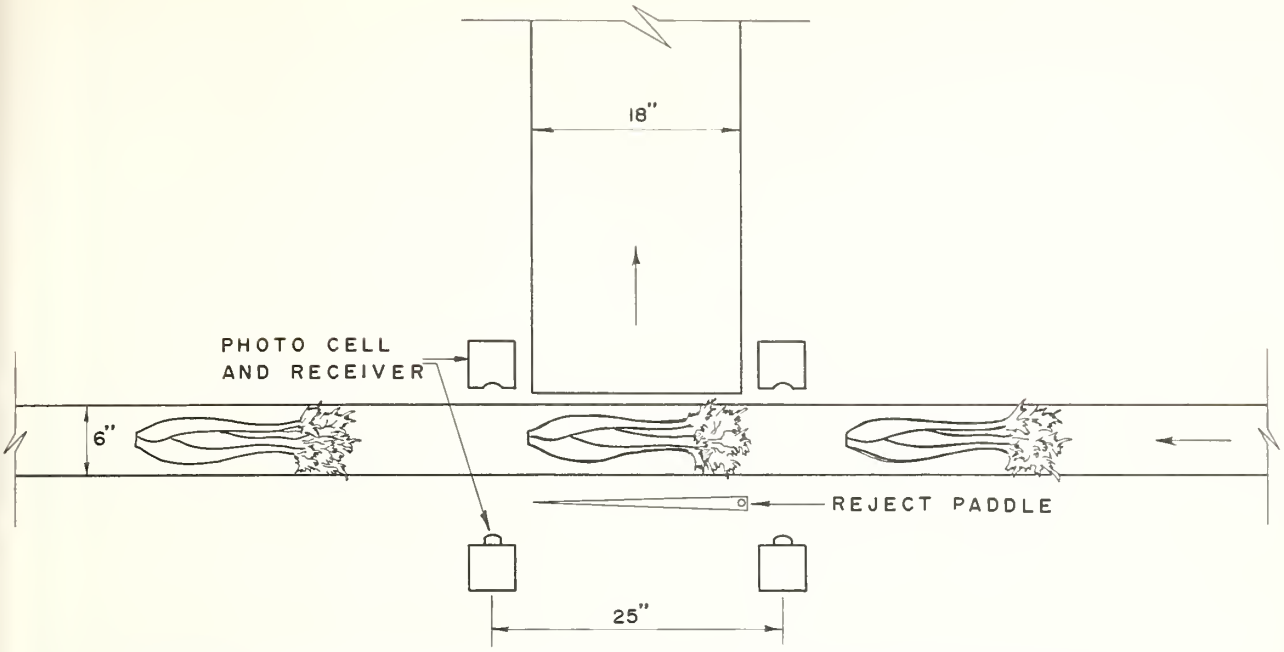


FIGURE 10.—Sketch of photoelectric cell-operated reject system for celery stalks too closely spaced.

belt. A better design would have ribbed construction on the platform. The ribs should run parallel to the direction of travel of the belt. Water between the belt and the platform would thus have no effect on drag imposed on the belt.

Scale and Spacer Belt Adjustments

The accuracy of the three-channel electronic scale was quite high during laboratory tests. However, when the scale was field tested with the stalk

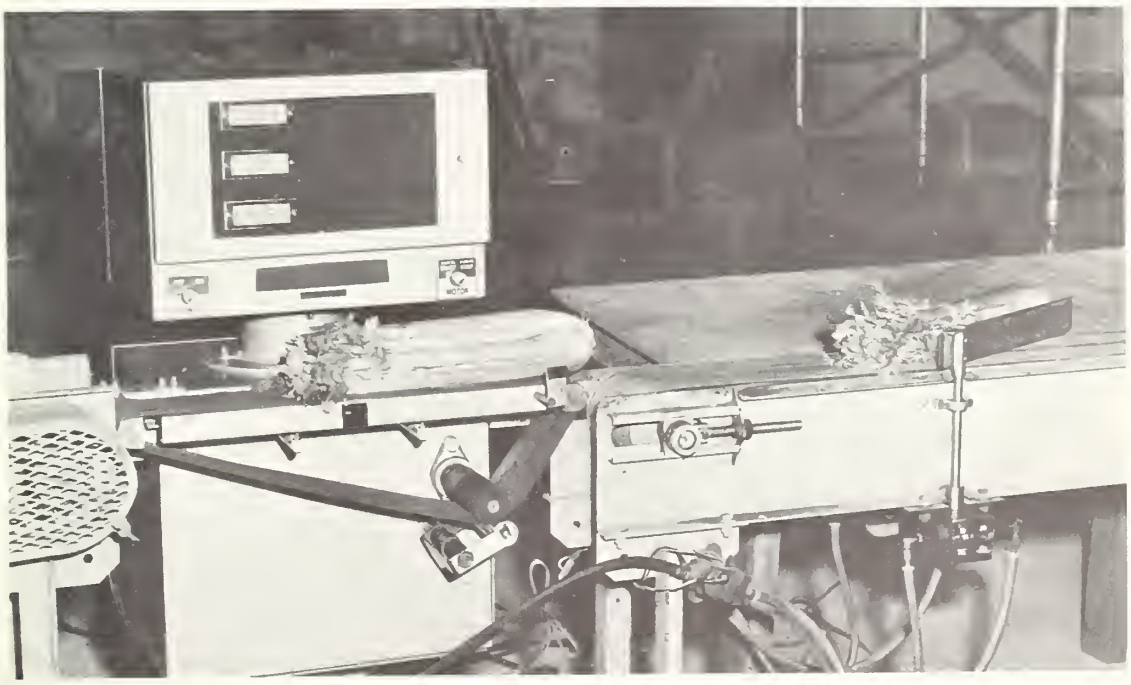


FIGURE 11.—Paddle diverting celery stalk from sizer conveyor.

spacer conveyor, overall accuracy of the system was reduced because of the large space required between celery stalks and the high belt speeds.

Although the effect of stalk spacing and belt speed on scale accuracy can be reduced, some spacing error can be expected from the drop chute and the stalk spacer conveyor. The standard deviation for stalks spaced with this spacing system is 2.7 inches. The significance of this standard deviation is that if only 10 percent of the stalks are spaced with less than 9 inches of clear space between them, then the average clear space between stalks must be 12.5 inches.

To average 12.5-inch clear spaces between stalks, at 200 stalks per minute, the weighing platform belt speed must be adjusted to 475 feet per minute. This is a high rate of travel and will cause additional stalk handling problems.

A few minor adjustments on the machine seemed to reduce the number of errors caused when stalks were closely spaced and traveling at high rates of speed: Damper adjustment; differential in speed of the weighing platform belt compared with the speed of the final spacer belt; and elevation of the spacer belt compared with that of the weighing platform.

The scale seemed to weigh more accurately when the damper adjustment knob was turned one-half revolution toward less damping. Increased damping caused the scale to misclassify all stalks.

Weight separation was more accurate when the speed of the weighing platform belt was adjusted to 10 feet per minute faster than the speed of the final spacer belt.

Transfer of the stalk from the spacer belt to the weighing platform was also important. Transfer was improved if the spacer belt was approximately one-half inch higher than the weighing platform.

Two-Channel Electronic Scale

During field tests of the three-channel electronic scale, it became evident that the potential scale accuracy would not be fully realized because of the stalk spacing requirements and handling problems.

Because of this, a different type of electronic scale was tested. Rather than separating stalks into three weight groups, this scale was a two-channel classifier that separated stalks into two weight groups (fig. 12).

The potential accuracy of this scale was comparable to that of the three-channel classifier. However, fewer problems were encountered when the scale was tested with the stalk spacer belts because of reduced stalk spacing requirements and better stalk diversion.

The two-channel electronic scale satisfactorily separated celery stalks into two categories with 5 to 6 inches of clear space between stalks. The three-

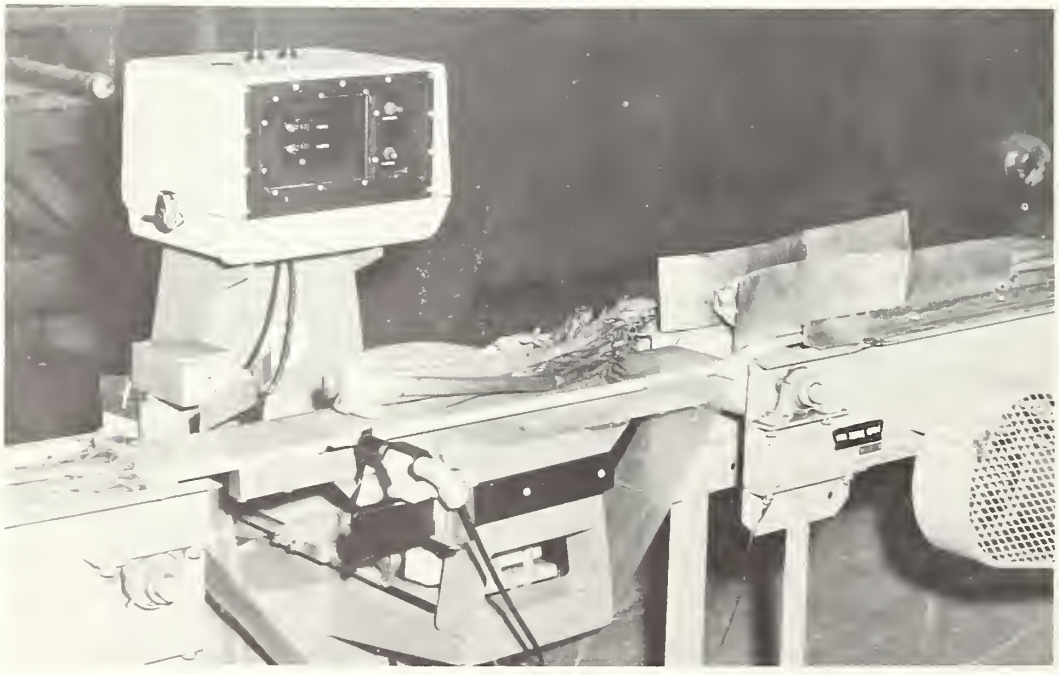


FIGURE 12.—Two-channel electronic scale with celery stalk on weighing platform.

channel scale required 9 inches of clear space. Variance in stalk spacing of the two-channel scale was such that fewer than 10 percent of the stalks had less than 6 inches of clear space between stalks, with an average clear space of 9½ inches. With this spacing, the weighing platform belt speed should be 425 feet per minute for a feed rate of 200 stalks per minute.

The tip of the stalk diverter paddle of the two-channel scale pointed downstream. This eliminated the problem of stalks piling up on the conveyor. In a commercial operation, stalks of one size group would be transported at this point from the stalk diverting mechanism, to the take-away conveyor, and then to packing stations. Larger stalks would be transported by conveyor to the next electronic scale in the line.

Other Sizing Equipment and Methods

Several other methods can be used to size celery. The first is a monorail conveyor sizer working on a weight principle; a second is hand-sizing as presently practiced on celery-packing mule trains; and a third is a dimension sizer that measures diameter of celery butts. The dimension sizer was not evaluated for this study.

Monorail Conveyor Sizer

This sizer is a mechanical-beam type of the same basic design as those used in poultry eviscerating plants to size carcasses. An overhead monorail conveyor, from which carriers are suspended, moves the stalks past several weighing stations (fig. 13).

At each weighing station, a balanced beam is attached to a 3-inch-long section of the carrier channel. When the weight of the celery stalk plus the carrier is sufficient to depress this short section of conveyor track, a mercury switch sends current to a four-way electric air valve. Air pressure operates a reject cylinder to trip a lock on the carrier hanger and the celery stalk falls onto a conveyor belt that carries the stalks to packing stations. Smaller stalks proceed along the conveyor to other weighing stations.

The scale accuracy of the monorail conveyor sizer was evaluated and compared with that of the three-channel electronic scale. Celery stalks that had been sized with the monorail conveyor

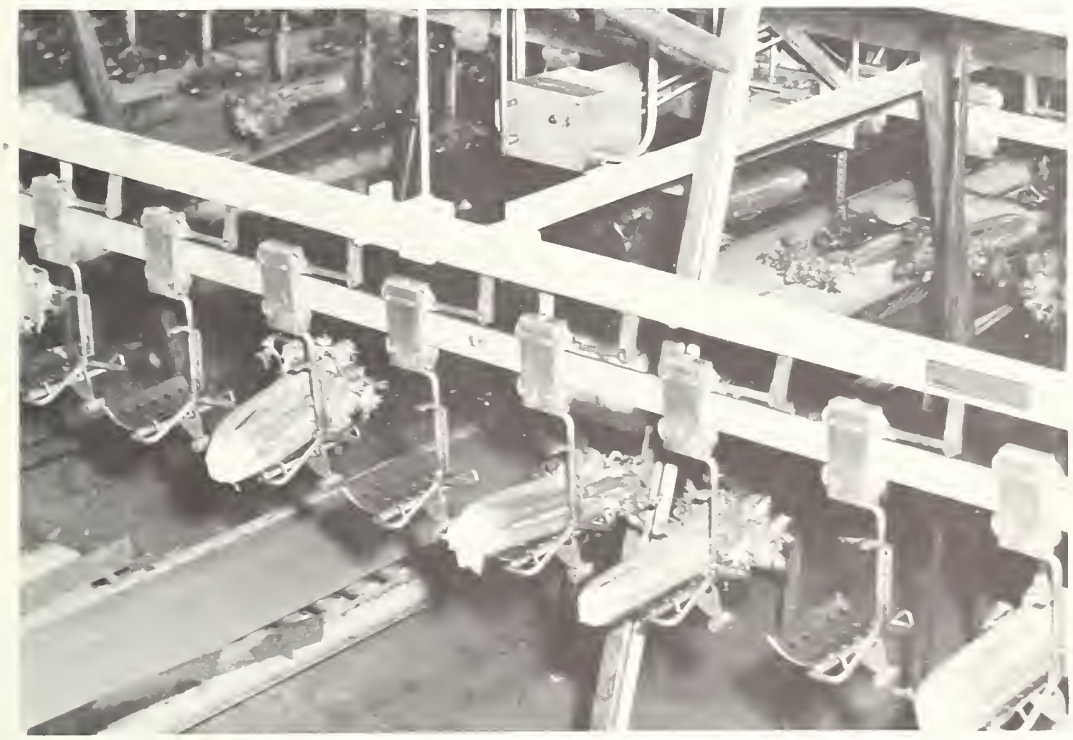


FIGURE 13.—Monorail conveyor sizer with celery stalks in position on carriers.

sizer in a commercial packinghouse were selected at random from several weighing stations and individually weighed. With the conveyor speed set to deliver approximately 90 stalks per minute to the weighing stations, the zone-edge width was ±0.088 pound.

Although the monorail conveyor sizer was not as accurate as the three-channel electronic scale (±0.058 pound), it was sufficiently accurate to separate celery stalks into size categories. Celery sized by this equipment was uniform in size and the lid of the packed crates bulged slightly.

Hand-Sizing Method

Based on the distribution of stalk size obtained by Gull during his weight and diameter measurements, the zone-edge width of celery stalks hand-sized and packed on mule trains was ±0.394 pound. This method did not compare well with any of the mechanical sizers tested and actually was not accurate enough to produce a uniform pack. There was considerable overlap of celery sizes within the crates and the weights of the packed crates varied as much as 15 pounds.

Initial Equipment Cost

Installation of a monorail conveyor sizer system capable of separating about 200 stalks per minute into six size categories will require two conveyor lines and will cost approximately $17,000. For a packinghouse to handle 1,000 crates per hour, six conveyor lines will be required at an initial cost of about $51,000 for equipment.

By comparison, installation of a sizing system composed of two-channel electronic scales capable of handling 1,000 crates per hour will require 13 weighing units plus stalk spacer belts and conveyors between scales. The initial cost for this equipment will be approximately $43,000.

Conclusions and Recommendations

Tests conducted with the sizers showed that it is feasible to mechanically separate celery stalks by weight. All the mechanical sizers tested are sufficiently accurate to give a uniform pack with only a small variation in the weight of packed crates.

The electronic scales have several advantages. Their relatively small size allows more freedom when selecting a packinghouse layout; additional units can easily be added during periods of expansion; they are potentially more accurate; and the initial cost for the equipment is less than that of the monorail conveyor sizer.

Of the electronic scales, the two-channel classifier is recommended. With two-channel separation, stalk spacing problems are minimized. Also, the stalk weight range for any one size category is much easier to establish. Instead of setting the weight control at the midpoint of the size range and adjusting the weight range control dial until the desired weight range is established, as is required with the three-channel classifier, the upper weight limit of the size category is set on the scale. Stalks weighing more than this weight will be passed to the next scale. The upper weight range of the next larger stalk size is set on the next scale in the line to achieve proper stalk separation.

The monorail conveyor sizers have the advantage of being past the experimental stage. Stalk spacing is not a problem with this equipment and it is readily adaptable to sizing celery stalks without major modifications.

Both the electronic scale and the monorail conveyor sizers will separate celery stalks into size categories fast enough to make them commercially acceptable. Final selection of equipment should depend on costs, accuracy requirements, and the personal preference of the packinghouse manager.

The hand-sizing method has been shown to be inadequate for separation of stalks into uniform size groups and is not recommended for use in a central packinghouse.

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